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D'APPOLONIA CONSULTING ENGINEERS INC PITTSBURGH PA
NATIONAL DAM INSPECTION PROGRAM. TYRONE RESERVOIR 2 (NDI ID535)--ETC(U)
SEP 78

F/G 13/2

DACW31-78-C-0049

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National Dam Inspection Program.
Tyrone Reservoir 2 (NDI 535)
Susquehanna River Basin, Sink Run,
Blair County, Pennsylvania. Phase I
Inspection Report.

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: Tyrone Reservoir No. 2
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Blair
STREAM: Sink Run, secondary tributary of the Little Juniata River
DATE OF INSPECTION: July 12 and 18, 1978

ORIGINAL CONTAINS COLOR PLATES: ALL DDO
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ASSESSMENT: Based on the evaluation of the conditions as they existed on the dates of inspection and as revealed by visual observations, the condition of Tyrone Reservoir No. 2 is assessed to be poor and to require further investigation to evaluate the existing seepage conditions and appropriate measures for controlling seepage through the embankment.

Field observations showed various seepages along the toe of the dam and the area below the toe of the dam was found to be swampy. Accumulation of silt at the seepage points on the sides of the outlet pipe headwall suggests internal erosion of the embankment. High and thick brush in the swampy areas below the toe of the dam precluded adequate visual inspection of these areas. This brush should be cut and removed to permit future visual inspections.

The spillway capacity is classified to be "seriously inadequate" (43 percent PMF), because it is estimated that overtopping would result in failure of the dam and damage potential would be significantly higher from that which would exist prior to overtopping.

It is recommended that the owner reevaluate the spillway capacity using more accurate analysis techniques.

It is further recommended that the owner provide around-the-clock surveillance during unusually heavy runoff to detect possible problems and develop a formal warning system to alert the downstream residents in the event of an emergency.



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for public release and sale; its
distribution is unlimited.

Lawrence D. Andersen
Lawrence D. Andersen, P.E.
Vice President

G. K. Withers 23 Sep 78
G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

This dam is considered unsafe in its
present condition.

TYRONE RESERVOIR NO. 2
 NDI 1.D. NO. 535
 JULY 12, 1978

Access to for	White Section	<input checked="" type="checkbox"/>
NIS	Buff Section	<input type="checkbox"/>
NOO	MANHOLED	
1.5' SECTION		
BY	DISTRICT/CONTRACT/ABILITY CODES	
	74	23
	CP	



Upstream Face



Downstream Face

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
TYRONE RESERVOIR NO. 2
NDI I.D. NO. 535
DER I.D. NO. 7-2

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. The dam consists of an earth embankment 820 feet long, with a maximum height of 51 feet from the downstream toe. The combined primary and emergency spillway is located on the left abutment (looking downstream). The flow through the chute spillway is controlled by an overflow section 80 feet wide at an elevation about 7 feet below the crest of the dam. Presently, the lake level has been raised by 2-foot-high flashboards installed across the spillway leaving a freeboard of 5 feet for the dam. The discharge channel of the spillway is a 6-foot-deep, 25-foot-wide rectangular channel with concrete walls and bottom. A series of steps in the spillway channel control the flow velocity. The outlet works consist of a 20-inch cast-iron blow-off pipe and a 14-inch cast-iron supply line, located through the middle of the dam. Drawings indicate that these pipes are encased in concrete and supported on masonry walls. Discharge through these pipes is controlled by valves located in an intake tower at the upstream end of the pipes. The 20-inch blow-off pipe constitutes the emergency drawdown facility for the dam.

b. Location. Tyrone Reservoir No. 2 is located on Sink Run immediately upstream of the pool of Tyrone Reservoir No. 1 about 2 miles west of Tyrone in Snyder Township, Blair County, Pennsylvania (Plate 1).

Spillway flow from Tyrone Reservoir No. 2 discharges into Tyrone Reservoir No. 1. Below Tyrone Reservoir No. 1, Sink Run flows about 3000 feet southeast, where it is diverted into Schell Run valley

through a flood control project constructed by the U.S. Army Corps of Engineers. It is reported by the Corps of Engineers, Baltimore District, that in the event of a dam failure, the flood control project's diversion dam would be overtopped and flow would follow the original course of Sink Run. Below the flood control project, Sink Run flows through residential areas and downtown Tyrone before discharging into Bald Eagle Creek, a tributary of the Little Juniata River, at Tyrone.

It is estimated that failure of Reservoir No. 2 would also result in failure of Reservoir No. 1 downstream, and the combined discharge would result in large loss of life and property damage in Tyrone.

- c. Size Classification. Intermediate (based on 51-foot height).
 - d. Hazard Classification. High.
 - e. Ownership. Borough of Tyrone (Address: Mr. Raymond B. Ervin, Jr., Borough Secretary, Tyrone Borough, 1100 Logan Avenue, Tyrone, Pennsylvania 16686).
 - f. Purpose of Dam. Water supply.
 - g. Design and Construction History. The dam was designed by the engineers of Tyrone Gas and Water Company and constructed by Vipond Construction Company starting in 1910. In 1911, while the dam was under construction, the embankment was overtopped during a flood, causing breaching of the embankment. The construction was completed in 1912.
 - h. Normal Operating Procedure. The reservoir is presently maintained at the crest level of the flashboards across the spillway, which is about five feet below the crest level of the dam as measured in this inspection. Elevations shown on the design drawings are relative to an arbitrary site datum. The U.S. Geological Survey (USGS) 7.5-minute Tipton quadrangle (photorevised in 1972) shows the pool elevation of Tyrone Reservoir No. 2 to be at Elevation 1222 (USGS Datum).
- 1.3 Pertinent Data. Elevations referred to in this and subsequent sections of the report were calculated based on approximate field measurements assuming the crest of flashboards to be at Elevation 1222 (USGS Datum) which is the pool elevation shown on the USGS map.
- a. Drainage Area - 5.9 square miles

b. Discharge at Dam Site (cfs)

Maximum known flood at dam site - 1000 in 1936 (28 inches over 75-foot-wide spillway)
Warm water outlet at pool elevation - N/A
Diversion tunnel low pool outlet at pool elevation - N/A
Diversion tunnel outlet at pool elevation - N/A
Gated spillway capacity at pool elevation - N/A
Gated spillway capacity at maximum pool elevation - N/A
Ungated spillway capacity at maximum pool elevation - 3000 with flashboard at Elevation 1227
Total spillway capacity at maximum pool elevation - 3000 with flashboard at Elevation 1227, 4000 without flashboard at Elevation 1227

c. Elevation (USGS Datum) (feet)

Top of dam - 1227
Maximum pool-design surcharge - N/A
Full flood control pool - N/A
Recreation pool (normal pool) - 1222 (top of flashboards)
Spillway crest - 1220
Upstream portal invert diversion tunnel - N/A
Downstream portal invert diversion tunnel - N/A
Streambed at center line of dam - 1178 (estimated)
Maximum tailwater - 1181.5 (in 1936)

d. Reservoir (feet)

Length of maximum pool - 1600+
Length of recreation pool (normal pool) - 1440 at Elevation 1222
Length of flood control pool - N/A

e. Storage (acre-feet)

Recreation pool (normal pool) - 460 @ Elevation 1222
Flood control pool - N/A
Design surcharge (maximum) - 575 at Elevation 1227
Top of dam - 575

f. Reservoir Surface (acres)

Top of dam - 24+ (estimated)
Maximum pool - N/A
Flood control pool - N/A
Recreation pool (normal pool) - 21
Spillway crest - 21 at Elevation 1222

g. Dam

Type - Earth
Length - 820 feet
Height - 51 feet
Top width - 10 feet
Side slopes - 2.0H:1V (upstream); 2.5H:1V (downstream)
Zoning - No
Impervious core - Yes
Cutoff - Yes
Grout curtain - No

h. Diversion and Regulating Tunnel

Type - 20-inch-diameter cast iron
Length - 200+ feet
Closure - Valve
Access - Valves at intake tower (tower is accessible by
boat only)
Regulating facilities - Valve

i. Spillway

Type - Overflow section with flashboards
Length of weir - 80 feet 6 inches (as measured)
Crest elevation - 1222 at top of flashboards
Gates - N/A
Upstream channel - Lake
Downstream channel - Variable width transition channel and
6-foot by 25-foot rectangular concrete discharge channel

SECTION 2
ENGINEERING DATA

2.1 Design

a. Data Available

(1) Hydrology and Hydraulics. No design data were found relative to the hydrology and hydraulics for the dam.

(2) Embankment. The available information includes a limited number of design drawings, various past state inspection reports, and correspondence.

(3) Appurtenant Structures. No design information is available.

b. Design Features. A review of design drawings and correspondence files for the dam shows the following main features of the project:

1. As designed, the dam is essentially a homogeneous embankment with 2 to 1 (horizontal to vertical) upstream slope and 1.5 to 1 downstream slope (Plate 2). The crest width of the dam was 15 feet and a 5-foot-wide bench was located on the downstream slope at about midheight of the dam. The upstream face of the dam was lined with puddle clay and protected by riprap. The clay was placed 2 feet thick at the top of the dam and 3 feet thick at the toe of the upstream slope and was joined to the puddle clay cutoff trench along the toe of the upstream slope.
2. In about 1919, the downstream slope of the dam was flattened from a 1.5 to 1 slope to a 2.5 to 1 slope (Plate 3). Two 10-foot-wide benches were constructed on the downstream slope at levels 12 and 30 feet below the crest of the dam. It appears that additional puddle clay was placed on the upstream face at the time of the downstream repairs to control seepage through the dam.

(2) Appurtenant Structures. The appurtenant structures consist of an uncontrolled spillway and outlet works. The spillway is equipped with two-foot-high flashboards installed under a state permit issued in 1967. Plan and profile of the spillway are shown in Plate 4. Plate 5 shows some of the details of the spillway repair

work conducted in 1956. Plate 6 illustrates the details of the flashboards across the spillway. The outlet works for the dam consist of a 20-inch blow-off line and a 14-inch supply line, both controlled by valves located at the intake tower.

c. Design Data

(1) Hydrology and Hydraulics. No design data are available.

(2) Embankment. No data are available on the design of the dam.

(3) Appurtenant Structures. There are no design data available for the appurtenant structures.

2.2 Construction. Limited construction drawings and various state inspection reports were available for review.

Records indicate that the dam was constructed during the period between 1910 and 1912 by Vipond Construction Company.

While the dam was under construction in 1911, it was overtopped during a flood, causing two breaches in the embankment. Because of this incident, which caused alarm in Tyrone, a court injunction was obtained by the Borough of Tyrone preventing the Tyrone Gas and Water Company from proceeding with the construction until the plans and construction of the dam were reviewed by a board of engineers.

The Water Supply Commission of Pennsylvania also inspected the dam and reported to the governor that "... as the method of construction of Dam No. 2 does not show that neatness, which is reassuring as to the care of detail, there is cause to question the integrity of the structure and the dam should not be allowed to fill except under state supervision."

A report dated October 10, 1911, covering an inspection made for the purpose of determining whether or not the board of engineers' recommendations were being followed reported that "... in some cases the work was proceeded with to such an extent in disregard of the recommendations as to preclude the possibility of being interpreted as mere mistakes and oversights."

In 1916, the dam was inspected by a private consulting engineer retained by the state. The report recommended that the downstream slope of the embankment should be flattened from a 1.5 to 1 slope to a 2.5 to 1 slope. It was further recommended that porous material should be used for this fill to avoid saturation of the added material. Available information indicates that these recommendations were implemented in about 1919.

In spite of these repairs, subsequent reports indicate that seepage problems at the toe of the dam persisted.

In 1935, several depressions were observed on the upstream slope of the embankment. These areas were excavated several feet deep and backfilled with "select material." The same report indicated that, ". . . water in the pool below the blow-off pipe continues to be quite cloudy."

A memorandum dated March 14, 1941, indicates that heavy seepage was observed on both ends of the headwall of the blow-off pipe. Other available information indicates continued seepage problems at the dam.

2.3 Operation. There are no formal operating procedures for the dam. The spillway of the impoundment is uncontrolled and has no operational features. The blow-off pipes for the dam are controlled by the valves located at the intake tower.

2.4 Other Investigations. Available information includes the following reports in addition to the state inspection and review reports.

- a. An inspection report signed by J. N. Chester, ASCE, W. C. Howley, ASCE, and W. G. Williams, ASCE (not dated - assumed to be March 31, 1911).
- b. An inspection report dated September 10, 1911, signed by C. W. Knight.
- c. An inspection report dated November 24, 1916, signed by Frederic R. Sterns.

2.5 Evaluation

a. **Availability.** The available engineering data were provided by PennDER.

b. Adequacy

(1) **Hydrology and Hydraulics.** No design information is available.

(2) **Embankment.** In view of the age of the dam, completed in 1912, available information does not provide quantitative geotechnical information to assess the adequacy of the design. However, various reports indicate that the dam was not constructed with proper care. The design does not include such basic elements as an internal drainage system or impervious core.

(3) **Appurtenant Structures.** Very limited information is available on the design of the outlet works. Plate 2 indicates that the blow-off and supply lines through the embankment were encased in concrete and supported on masonry walls.

c. Operating Records. No formal operating records are available for the dam. Correspondence dated April 29, 1936, indicates that during the flood in March 1936 the maximum depth of flow over the spillway was 28 inches.

d. Post-Construction Changes. As discussed in Section 2.2, the dam was enlarged in 1919 by the addition of fill on the downstream slope of the dam to reduce the slope from 1.5:1 to 2.5:1.

In about 1919, the length of the spillway crest was increased from 50 feet to 75 feet.

In 1956, repairs were made to the spillway channel.

e. Seismic Stability. The dam is located in Seismic Zone 1 and static stability of the dam is considered to be adequate. Therefore, based on the recommended criteria for evaluation of seismic stability of dams, the structure is assumed to present no hazard from earthquakes.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Tyrone Reservoir No. 2 consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.
2. Visual examination of the spillway and its components, the downstream end of the outlet pipe, and other appurtenant features.
3. Observation of factors affecting the runoff potential of the drainage basin.
4. Evaluation of downstream area hazard potential.

The specific observations are illustrated in Plate 7 and in the photographs in Appendix C.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features. High and thick brush in the swampy areas below the toe of the dam precluded adequate inspection of the toe and areas below the toe.

The most significant problem at the site is the presence of numerous seeps along the toe of the dam, located on the right side of the blow-off pipe. At least six seepage points were observed. Estimated seepage flows ranged from 5 to 30 gallons per minute (Plate 7).

Flow from the blow-off pipe discharge channel is estimated to be 100 gallons per minute, apparently fed by numerous seeps along the sides of the channel and seeps on each side of the blow-off pipe headwall. Accumulation of silt at seepage points around the headwall indicates possible internal erosion of the embankment.

Various bulges in the upstream riprap were observed, located about 6 to 8 feet below the crest of the dam. They were attributed to creep of riprap.

c. Appurtenant Structures. The spillway structures, spillway crests, channels, and plunge pool were examined for deterioration or

other signs of distress and obstructions that would limit flow. In general, the structures were found to be in fair condition. The blow-off pipe valve for the dam was operated by borough personnel and was observed to be functional.

d. Reservoir Area. A map review indicates that the watershed is predominantly covered with woodlands. The shorelines are not considered to be susceptible to massive landslides which would affect storage volume of the reservoir or cause overtopping of the dam by displaced water.

e. Downstream Channel. The spillway of the Tyrone Reservoir No. 2 directly discharges into Tyrone Reservoir No. 1. Downstream from Tyrone Reservoir No. 1, Sink Run flows about 3000 feet southwest where it is diverted to an adjacent valley by the U.S. Army Corps of Engineers' flood control project. The original course of Sink Run goes through residential areas and downtown Tyrone and joins Bald Eagle Creek west of Tyrone. Photographs in Appendix C illustrate the course of Sink Run through Tyrone.

3.2 Evaluation. The general condition of the dam is considered to be poor.

The most significant condition at the dam appears to be the seepage exiting around the headwall of the blow-off pipe and numerous other seepages along the toe on the right side of the blow-off pipe. Accumulation of silt at seepage locations around the headwall of the pipe suggest internal erosion of the embankment.

SECTION 4 OPERATIONAL FEATURES

4.1 Procedures. Review of the design drawings and field observations indicate that there are no formal procedures for operating the dam. The operational feature of the dam which may affect the safety of the dam is the blow-off pipe valve, if it is required to lower the reservoir.

The clearing of debris from the spillway as required and the continued inspection of the facilities by the dam tender are the principal maintenance operations which would affect safety.

4.2 Maintenance of the Dam. The overall maintenance conditions of the dam are considered to be poor. Removal of the brush from the toe area and annual mowing of the grass is required.

4.3 Maintenance of Operating Facilities. The blow-off pipe valve was operated by borough personnel and observed to be functional. Visual observations indicate that the operating equipment is in fair to poor condition. The intake tower where the valve for the blow-off pipe is located has no bridge; it is only accessible by boat.

4.4 Warning System. No formal flood warning system exists for the dam. The dam is maintained by borough personnel operating from Tyrone, about 2 miles from the site. No communication facilities are available at the site.

4.5 Evaluation. The operational condition of the dam is considered to be fair. The blow-off valve was operated and observed to be functional. The maintenance condition of the operating equipment is considered to be fair. The dam is accessible by a narrow road, therefore, access to the site may be difficult during severe weather conditions for inspection and emergency action.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Tyrone Reservoir No. 2 has a watershed area of 5.9 square miles and impounds a reservoir with a surface area of 21 acres at normal pool level. An 80-foot-wide spillway constitutes both the primary and emergency spillway for the impoundment. The spillway is equipped with a 2-foot-high flashboard across its crest. As it exists, the spillway has a maximum discharge capacity of 3000 cfs with no freeboard. The spillway capacity is estimated to be 4000 cfs without the flashboard and with no freeboard.

Tyrone Reservoir No. 1, which impounds a lake with a surface area of 15 acres at normal pool level, is located immediately downstream of this dam.

It is estimated that failure of Tyrone Reservoir No. 2 would also result in failure of the downstream reservoir.

b. Experience Data. Tyrone Reservoir No. 2 is classified to be an "intermediate" size dam in the "high" hazard category. Under the recommended criteria for evaluating emergency spillway capacity, such impoundments are required to pass full PMF.

The adequacy of the spillway was analyzed based on the simplified procedure and the hydrological data provided by the U.S. Army Corps of Engineers, Baltimore District. According to the Hydrology and Hydraulics Branch of the Baltimore District, the PMF would have a peak flow of 1639 cfs per square mile, which corresponds to 9700 cfs for the drainage area of the dam and a volume of 8200 acre-feet, equivalent to 26 inches of runoff. These values are greater than the spillway capacity of 4000 cfs with flashboards collapsed and surcharge storage volume of 115 acre-feet. Therefore, the spillway is not capable of passing the PMF flow without overtopping. Further analysis, according to the procedure, indicated that the spillway can pass a maximum flow of approximately 43 percent of the PMF without overtopping if the flashboards collapse as designed during this flow and 32 percent PMF if the flashboards fail to collapse.

c. Visual Observations. On the date of inspection, no conditions were observed that would indicate that the spillway of the dam could not operate satisfactorily in the event of a flood.

d. Overtopping Potential. As stated above, the dam will be overtopped during a flood whose magnitude exceeds 43 percent PMF.

e. Spillway Adequacy. As previously stated, the capacity of the spillway is less than 50 percent PMF. It is estimated that

overtopping of the dam would result in failure of the dam and downstream damage potential would significantly increase compared to that which would exist just before overtopping failure.

Based on the above results, the spillway is classified to be "seriously inadequate" according to the recommended criteria.

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. As discussed in Section 3, the field observations did not reveal any signs of distress that would significantly affect the short-term stability of the dam at this time.

However, in view of the presence of a significant amount of seepage from the toe of the dam, some showing signs of internal erosion of the embankment, and swampy areas below the toe, a quantitative evaluation of the effect of these conditions on the performance of the embankment is needed.

b. Design and Construction Data

(1) Embankment. The dam was designed at a time (1910) when limited understanding of the geotechnical behavior of earth structures existed. Consequently, the available design and construction information includes limited quantitative data to aid in the assessment of embankment stability.

(2) Appurtenant Structures. No drawings are available on the design of the outlet works. Available information indicates that pipes through the embankment were encased in concrete and supported on masonry walls extending to firm ground.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. As discussed in Section 2.2, in 1919 additional fill was placed on the downstream slope. Details of this change are illustrated in Plate 3.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations and review of available information indicate that Tyrone Reservoir No. 2 is in poor condition. Although observations did not reveal signs of distress, such as slumps or cracks at this time, the extent of wet areas below the dam and the significant seepage from the toe indicate that further investigation is required to develop a method of controlling the seepage and to quantitatively evaluate the stability of the embankment.

The spillway is considered to be "seriously inadequate" because its capacity (43 percent PMF) is less than 50 percent PMF and because it is estimated that overtopping of the dam would result in failure which would significantly increase the hazard potential existing just prior to overtopping.

b. Adequacy of Information. The available information in conjunction with visual observations and previous experience of the inspectors are considered to be sufficient to make a reasonable assessment of the dam.

c. Urgency. Further investigation of the dam and more detailed evaluation of the spillway capacity should be made immediately and other recommendations below should be implemented as soon as practicable or on a continuing basis.

d. Necessity for Further Investigation. The condition of the embankment and the capacity of the spillway are considered to require further investigation.

7.2 Recommendations/Remedial Measures

1. The stability of the dam and methods for controlling the seepage to prevent migration of fines from the embankment should be further evaluated by a professional geotechnical engineer, in view of the significant seepage from the toe and presence of swampy areas below the toe.
2. The owner should initiate additional studies to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide sufficient spillway capacity.

3. Brush and trees should be removed from the downstream face of the dam and for a distance of at least 50 feet below the toe of the dam to permit adequate inspection of these areas in future inspections.
4. It is recommended that the owner should provide around-the-clock surveillance during unusually heavy runoff and develop a formal warning system to alert the downstream residents in the event of an emergency.
5. It is recommended that the owner be advised that the dam and appurtenant structures should be inspected regularly and necessary maintenance should be performed.

PLATES

DRAWN BY	D.J.D.	CHECKED BY	JMP	DRAWING NUMBER	8-23-78
	7-25-78	APPROVED BY	BE		8-23-78



DRAWN BY
7-21-78

CHECKED BY
JHP

APPROVED BY
BE

DRAWING NUMBER
78-114-B107

SCALE OF PLAN, ONE INCH = 250 FEET

SINK RUN RESERVOIR No. 1

YANK TOWER

SINK RUN RESERVOIR No. 2

SECTION THROUGH DAM AND RESERVOIR No. 2

SCALE (PLAN), ONE INCH = 100 FEET

SCALE (SECTION), ONE INCH = 20 FEET

(PROPOSED)

SPILLWAY

SECTION E F

PLAN

Plans and Sections of
SINK RUN DAM AND RESERVOIR No. 2, AS PROPOSED, FOR
TYRONE GAS AND WATER COMPANY.

ALTOONA, Pa., MAY 24, 1910.

Henry Linton.

CONCRETE INCLUDING P.I.B.

CONCRETE INCLUDING P.I.B.

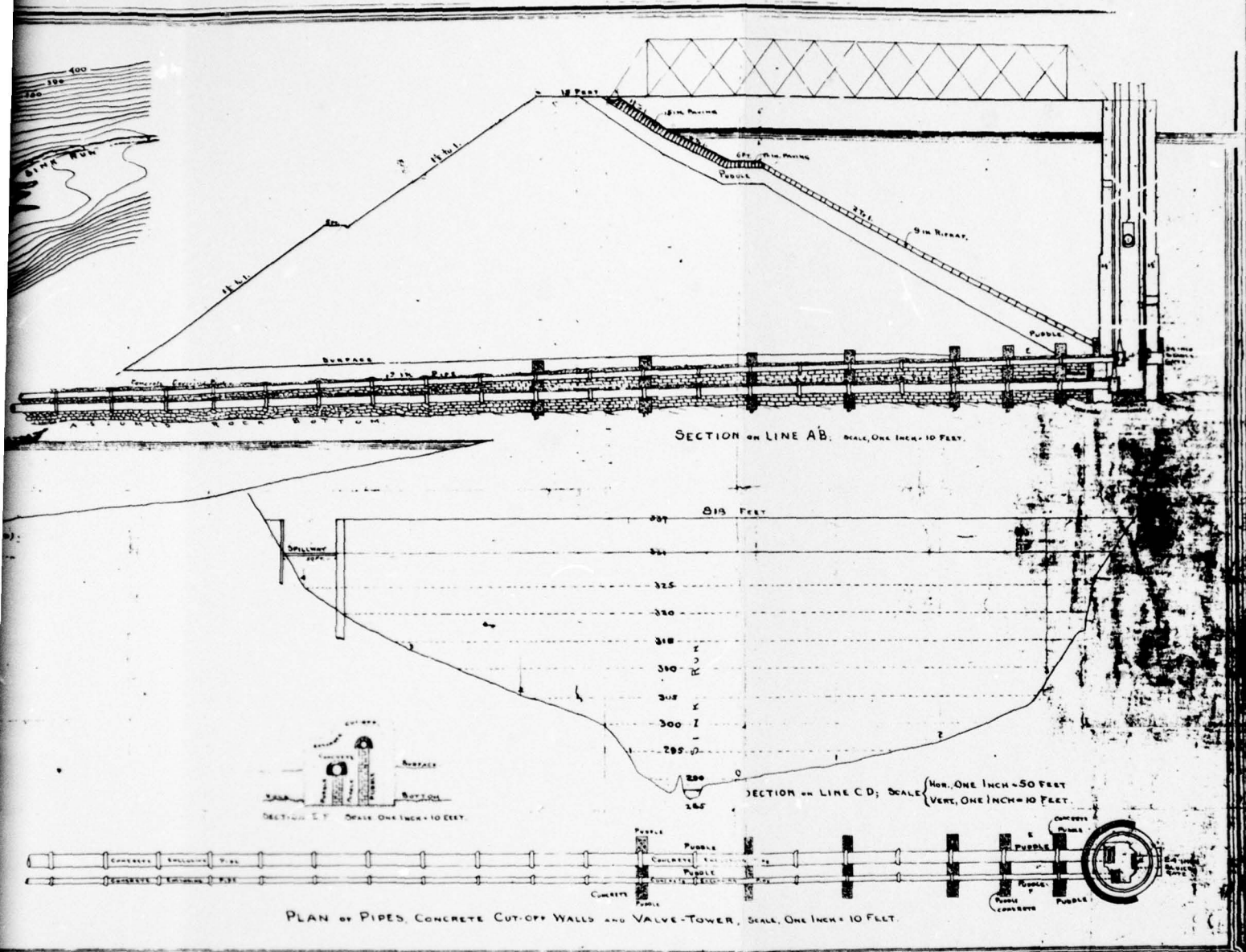
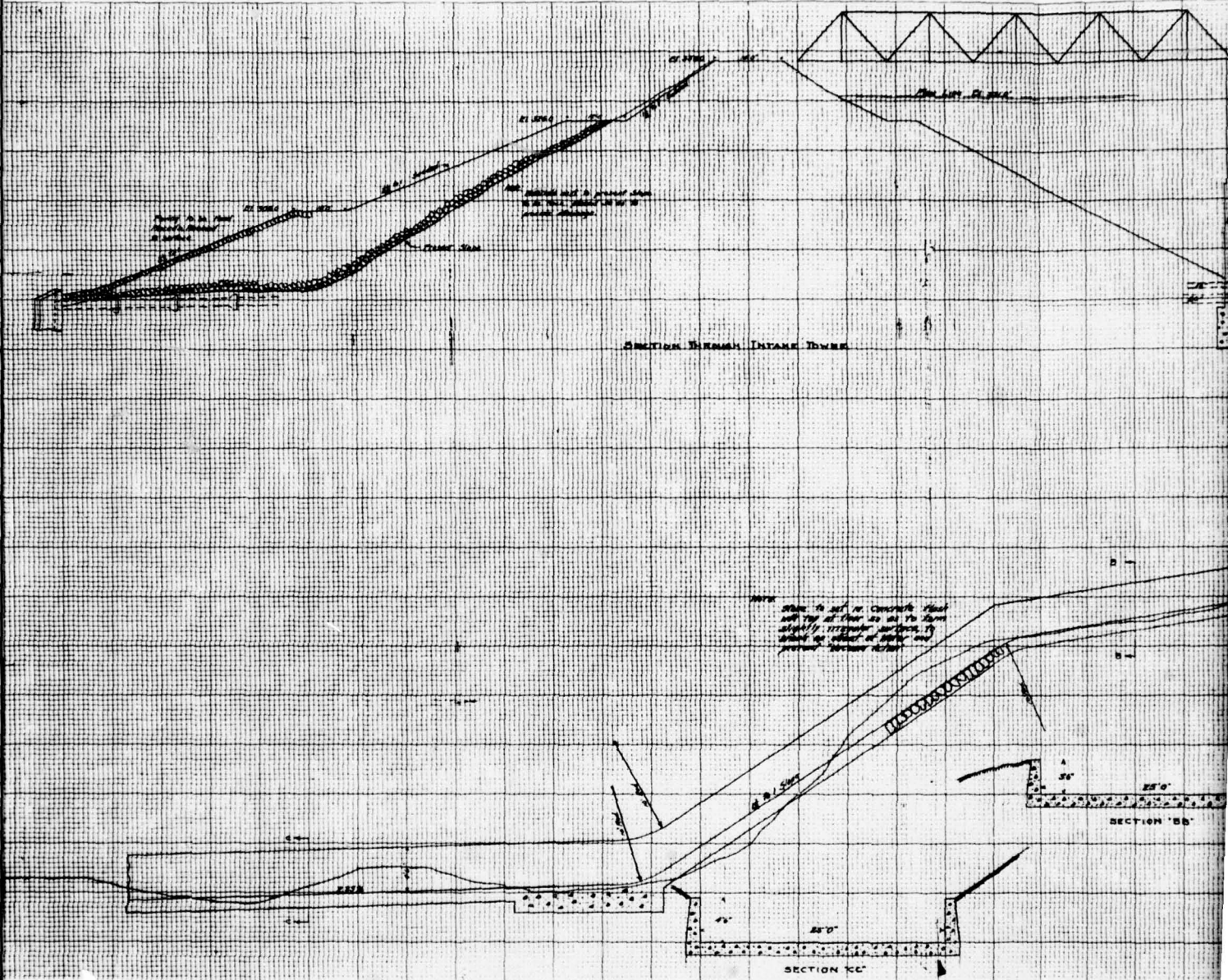


PLATE 2

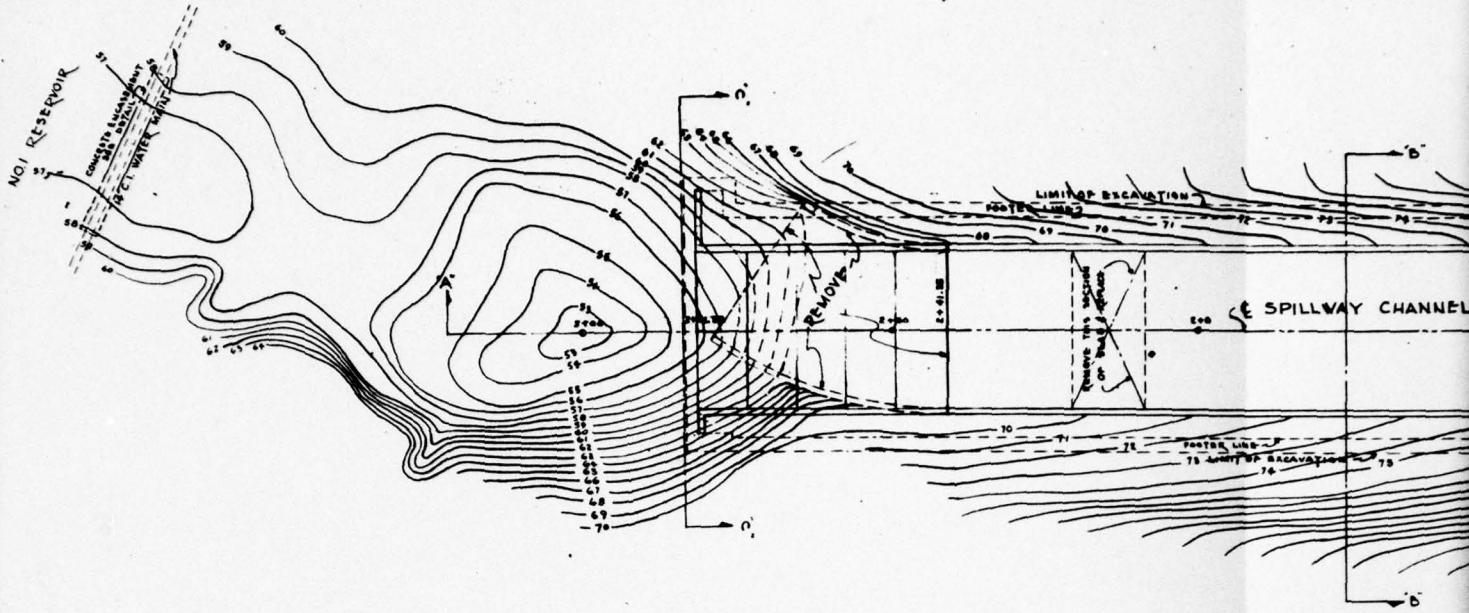
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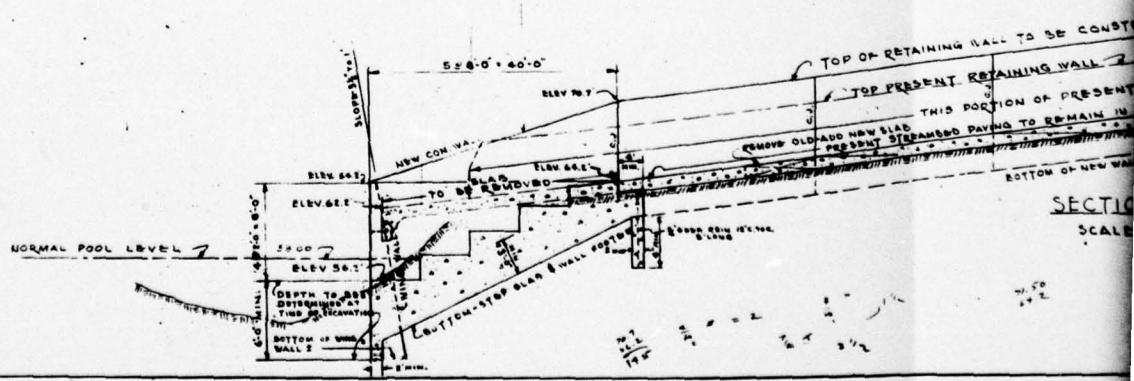
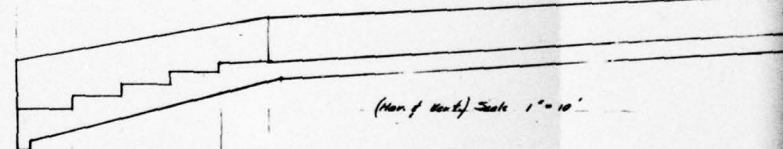
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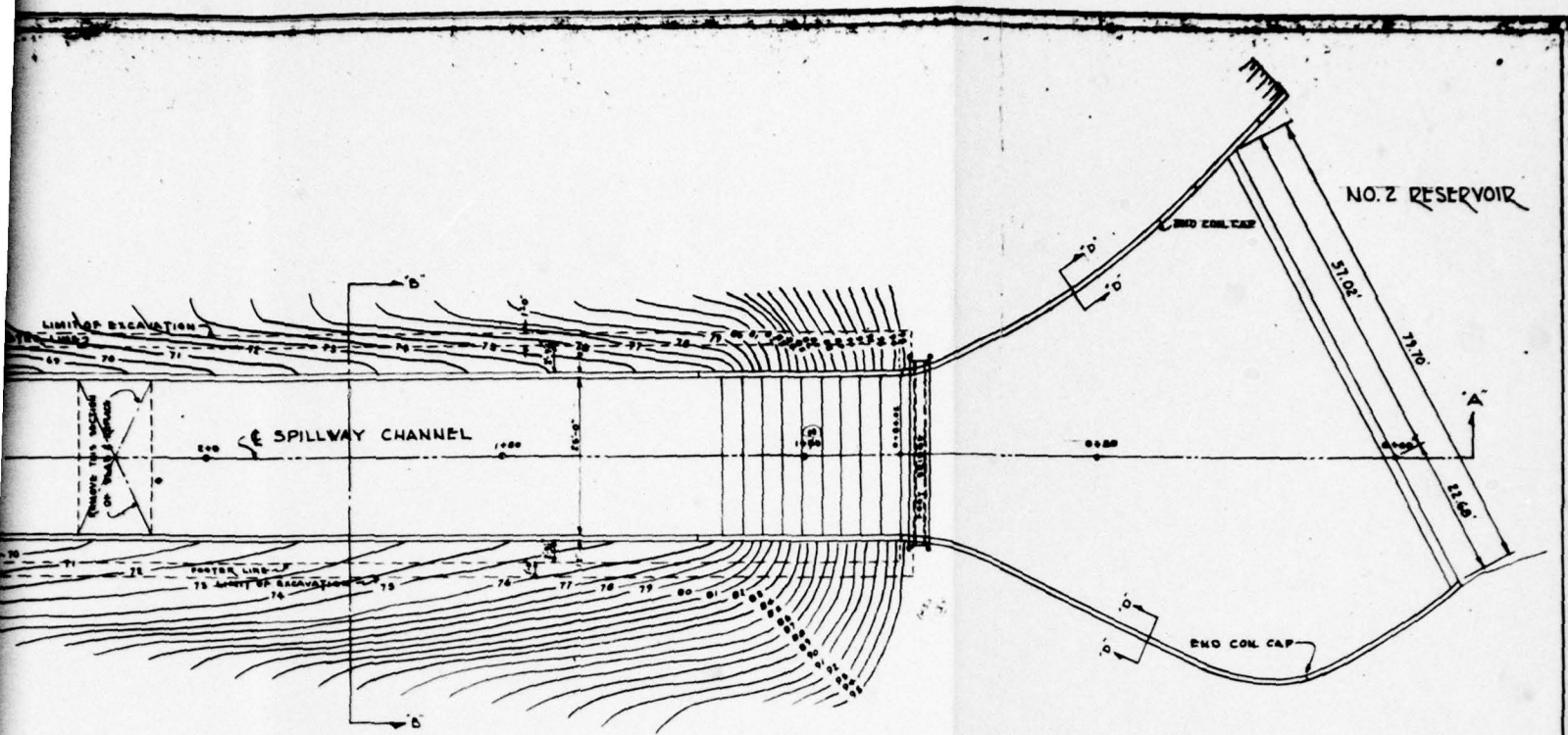


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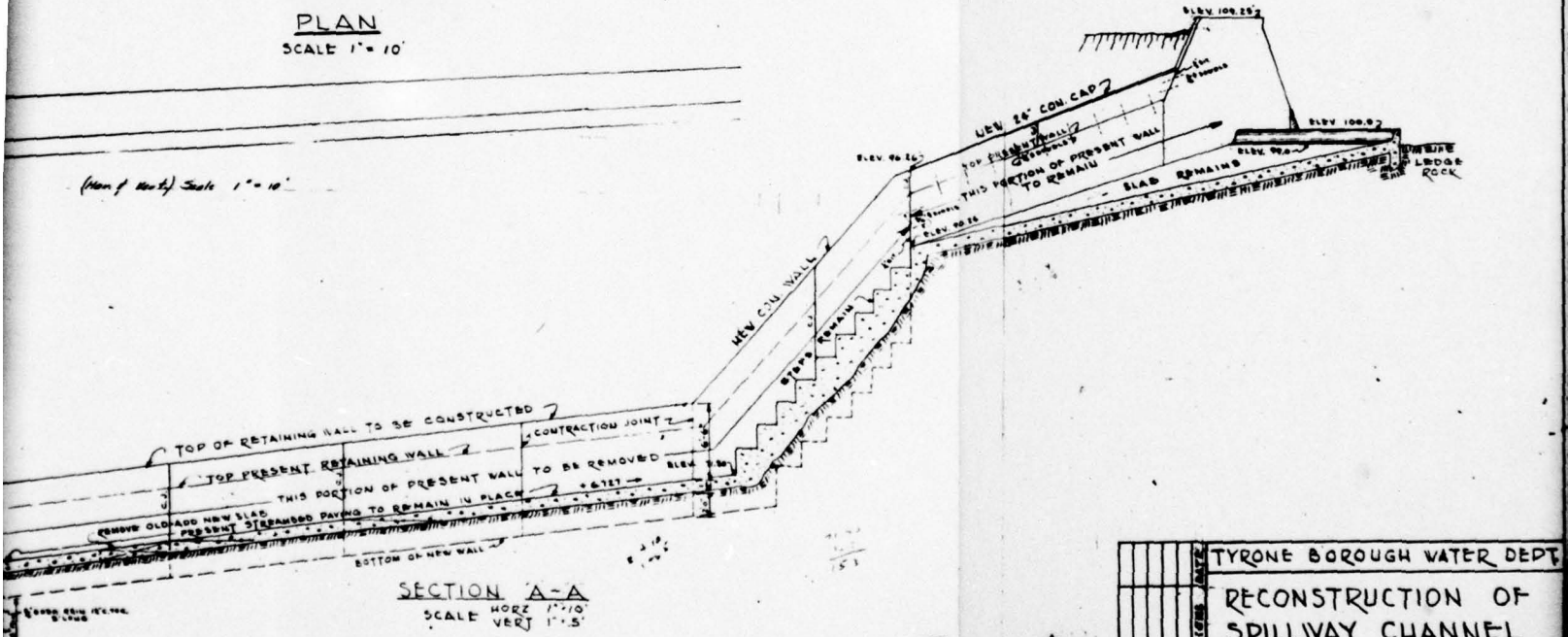


PLAN
 SCALE 1" = 10'





(Plan of No. 2) Scale 1" = 10'

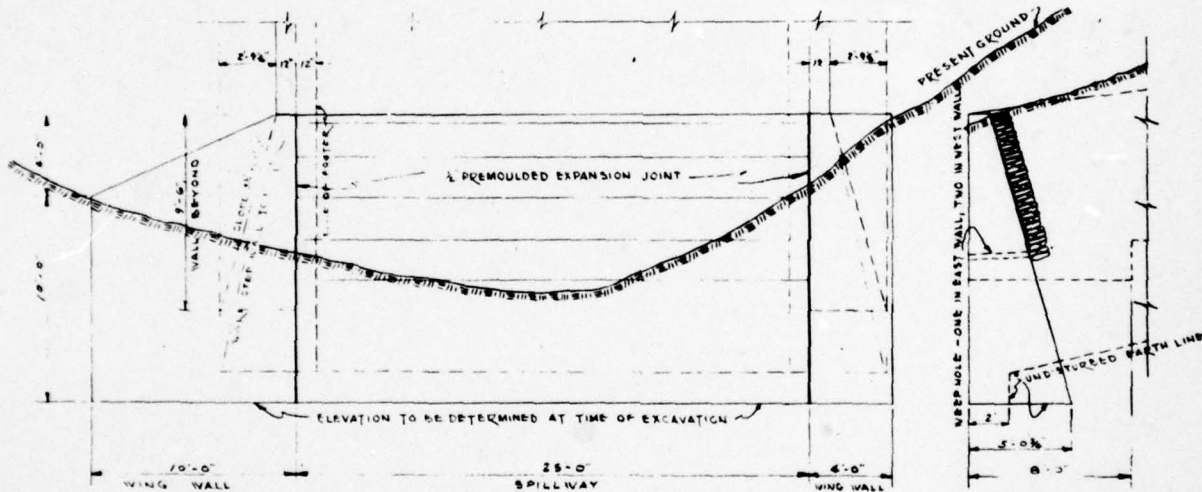
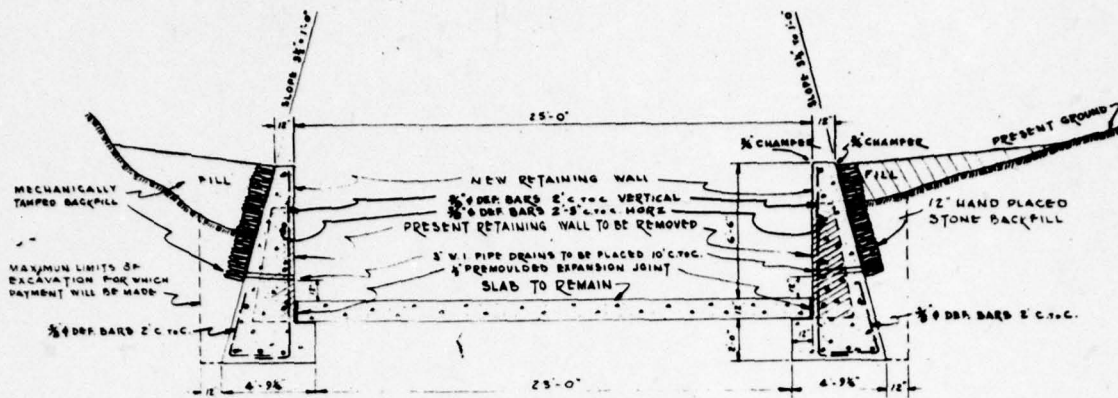


TYRONE BOROUGH WATER DEPT.		
RECONSTRUCTION OF SPILLWAY CHANNEL No. 2 DAM		
DATE	BY	CHKD BY
PUNK & MENGEL REGISTERED PROFESSIONAL ENGINEERS		

PLATE 4

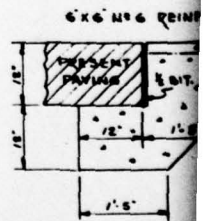
D'APPOLONIA

DRAWN BY D.J.D. CHECKED BY JHP 8-23-78 DRAWING 78-114-B109
 7-21-78 APPROVED BY BE 8-23-78 NUMBER

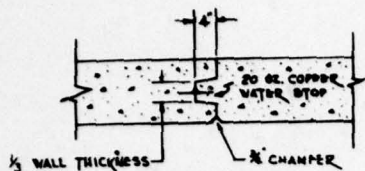


SECTION C-C
SCALE 1"=3'

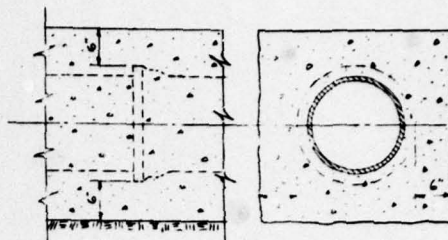
SECTION E-E
SCALE 1"=3'



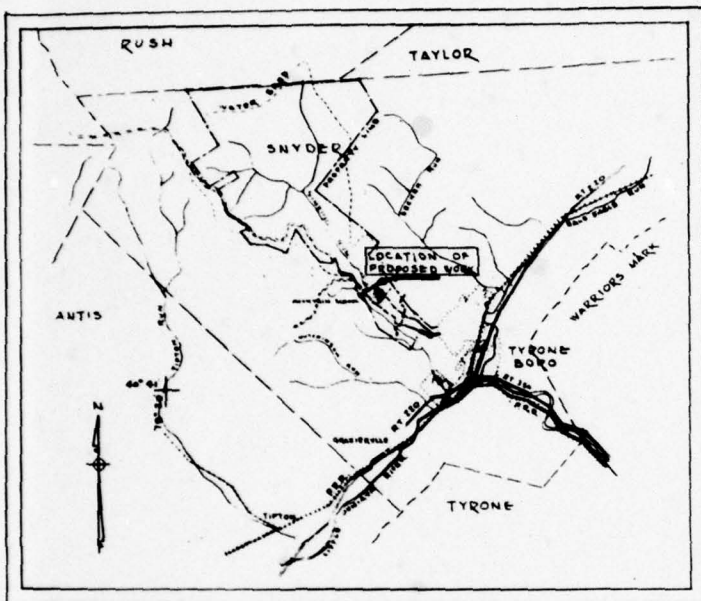
DETAIL OF S



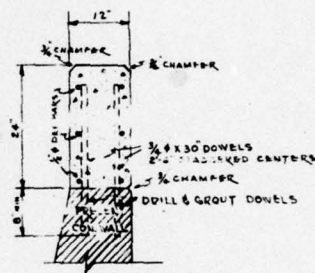
DETAIL OF CONTRACTION JOINT
NO SCALE



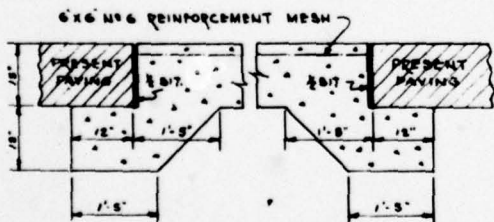
DETAIL OF 14" C.I. WATER LINE
ENCASEMENT
NO SCALE



LOCATION MAP
REPRODUCED U.S. GEOLOGICAL SURVEY
TYRONE & ALTOONA QUAD.



SECTION D-D
SCALE 1" = 1'-0"



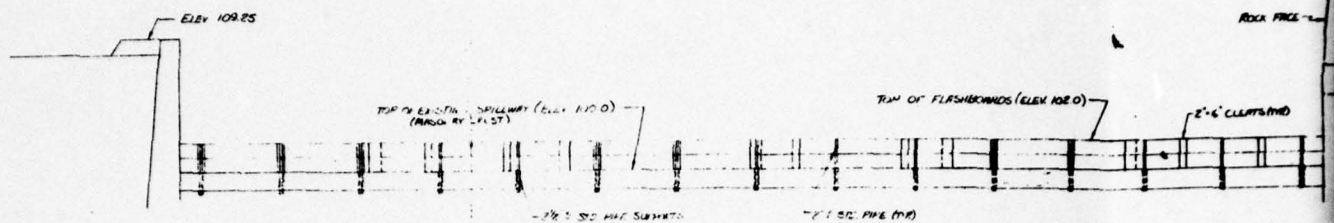
DETAIL OF STREAMBED REPAIR
SCALE 1" = 1'-0"



TYRONE BOROUGH WATER DEPT.			
RECONSTRUCTION OF SPILLWAY CHANNEL Nº 2 DAM			
DATE	JULY 1926	FILE Nº	
SCALE	AS SHOWN	REGISTERED PROFESSIONAL ENGINEERS TYRONE, PA.	SHEET Nº 2 OF 2

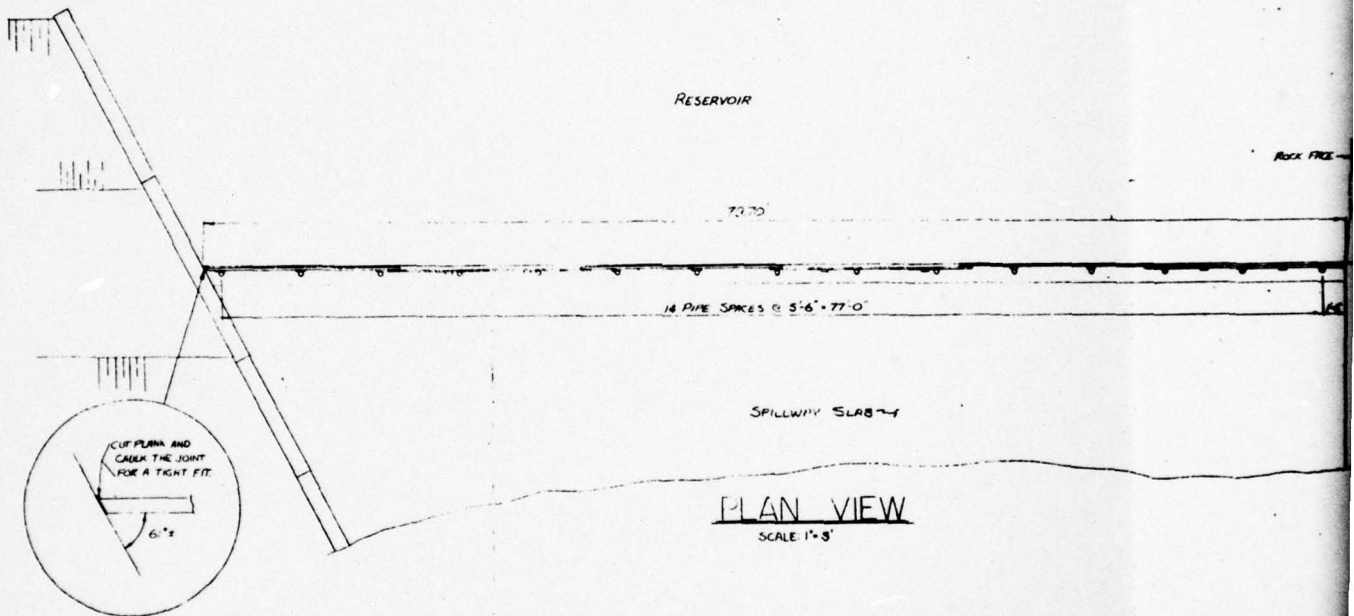
PLATE 5

D'APPOLONIA



ELEVATION VIEW

SCALE: 1"=5'



PLAN VIEW

SCALE: 1"=5'

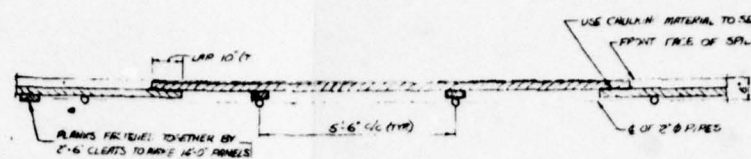
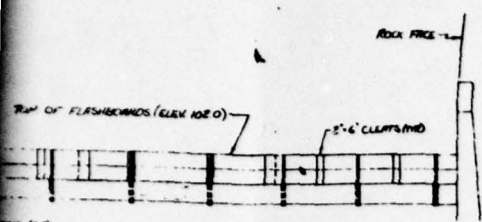
GENERAL NOTES

- 2" Ø STANDARD STEEL PIPE SHALL BE USED FOR THE FLASHBOARD PINS. IT SHALL HAVE THE FOLLOWING SPECIFICATIONS: YIELD POINT-35,000 PSI MINIMUM AND TENSILE STRENGTH-60,000 PSI MINIMUM. IT SHALL BE TYPE E OR S, GRADE B PIPE.
- 3" Ø HOLES SHALL BE DRILLED 1'-6" DEEP INTO MASONRY CREST AND THE 2 1/2" Ø STANDARD PIPE SUPPORTS SET INTO THEM. THE PIPE SUPPORTS SHOULD BE WEDGED OR GROUTED INTO THE HOLES TO MAKE THEM TIGHT. ALL HOLES MUST BE VERTICAL.
- PLANKS SHALL BE OF A STRUCTURAL GRADE, AND SHALL BE WELL SEASONED OR KILN DRIED LUMBER. THE LUMBER SHALL MEET NATIONAL LUMBER MANUFACTURERS SPECIFICATIONS.
- UNPLANED PLANKS MAY BE USED. IF THE PLANKS HAVE PLANED EDGES, ONE OF THE PLANKS IN A PANEL SHOULD BE A NOMINAL 2" x 16" SIZE AND THEN CUT SO THAT THE TOTAL DEPTH OF BOTH PLANKS IS EXACTLY 24".
- CAULKING MATERIAL SHALL BE USED BETWEEN THE PLANKS, AND BETWEEN THE PLANKS AND CONCRETE TO PREVENT LEAKAGE OF WATER THROUGH THE FLASHBOARDS.
- FLASHBOARDS MUST BE HELD TO THE PIPES. THIS MAY BE DONE BY NAILS DRIVEN INTO THE BOARDS AND BENT AROUND THE PIPES, OR BY USING WIRE.

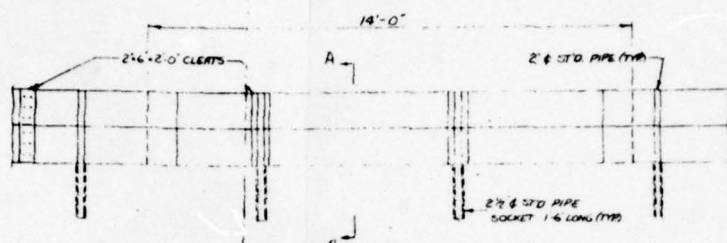
QUAN

2" Ø STANDARD PIPE
2 1/2" Ø STANDARD PIPE
PLANKS

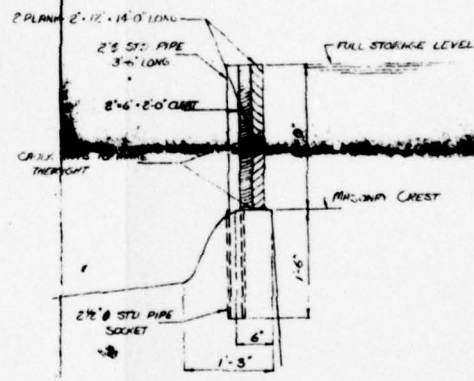
RECEIVED IN THE OFFICE OF THE WATER & POW.
RESOURCES DEPT. OF FOREST
WATERS ON THE DAY OF 16/11/54 A.D. IN
August 16/11/54
File Clerk



PLAN-TYPICAL SECTION
SCALE: 1/2" = 1'-0"




ELEVATION-TYPICAL SECTION



SECTION A-A
SCALE: 1" = 1'-0"

QUANTITIES	
2" Ø STANDARD PIPE	37.50 LIN. FT.
2" Ø STANDARD PIPE SOCKET	22.50 LIN. FT.
PLANKS	336 BOARD FT.

	REVISIONS	ISSUED	TYRONE BOROUGH WATER DEPARTMENT	SCALE AS NOTED
			CONSTRUCTION OF 2' FLASHBOARDS NO. 2 DAM	
APPROVED:	JOB G-3-48	GWIN ENGINEERS, INC. CONSULTING ENGINEERS ALTOONA - PENNSYLVANIA DRAWN BY JAL. CHECKED		SHEET NO. 1 OF 1

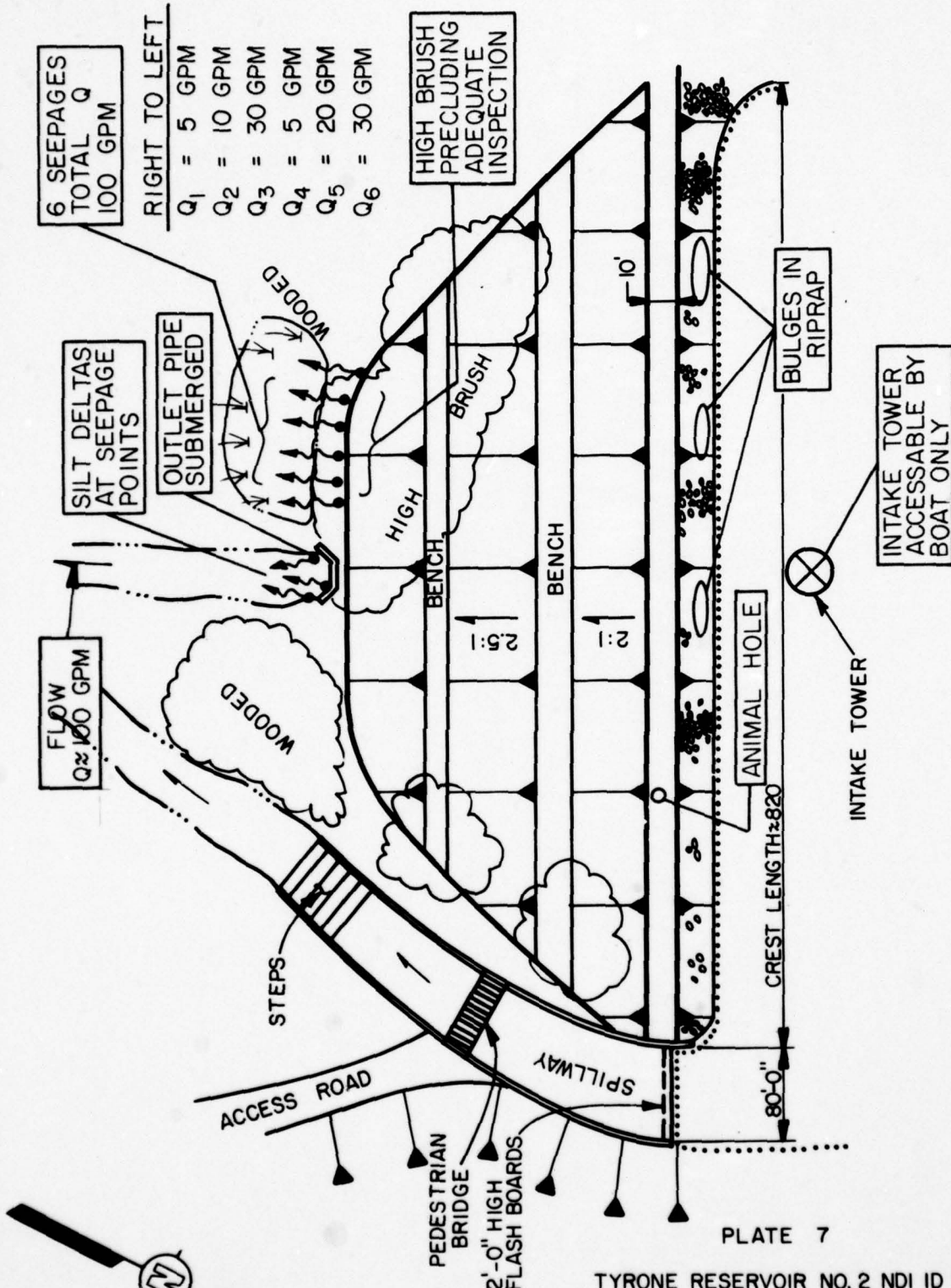


PLATE 7

TYRONE RESERVOIR NO. 2 NDI ID 535
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: JULY 12, 1978

D'APPOLONIA

POOL LEVEL DATE OF INSPECTION: 5' BELOW DAM CREST
NOT TO SCALE

APPENDIX A
CHECKLIST
VISUAL INSPECTION
PHASE I

CHECKLIST
VISUAL INSPECTION
PHASE I

NAME OF DAM TYRONE RESERVOIR #2 COUNTY BLAIR STATE PA. ID# NDI : 525
DE2 : 7-2

TYPE OF DAM EARTH FILL HAZARD CATEGORY HIGH.

DATE(S) INSPECTION JULY 12, 1978 WEATHER SUNNY TEMPERATURE 80's

POOL ELEVATION AT TIME OF INSPECTION 1222 M.S.L. TAILWATER AT TIME OF INSPECTION 1178 M.S.L.

INSPECTION PERSONNEL:

<u>BILGIN EREL</u>	<u>REVIEW INSPECTION BY:</u>	<u>ELIO D'APOLONIA</u>
<u>WAH-TAE CHAN</u>	<u>(JULY 18, 1978)</u>	<u>L.D. ANDERSEN</u>
		<u>JAMES POELLOT</u>

BILGIN EREL RECORDER

VISUAL INSPECTION
PHASE 1
EMBANKMENT

NAME OF DAM LYNDONE RES. #2

ID# NDI: 525 DEP: 7-2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	NONE FOUND.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE FOUND.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	NONE FOUND.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	NO PERCEIVABLE MISALIGNMENT.	
RIPRAP FAILURES	BULGES IN UPSTREAM SLOPE RIPRAP. ABOUT 1-2 FT BELOW NORMAL POOL LEVEL. (WERE SUBMERGED ON DATE OF INSPECTION)	

NAME OF DAM TYRONE RES #2
ID# NDI:535 DER:7-2

VISUAL INSPECTION
PHASE 1
EMBANKMENT

VISUAL EXAMINATION OF JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
NO VISUAL SIGNS OF DISTRESS, NO SEEPAGE		
ANY NOTICEABLE SEEPAGE	SEEPAGE AROUND DRAIN PIPE HEADWALL (ESTIMATED FLOW \approx 100 GPM) NUMEROUS SEEPS RIGHT OF DRAIN PIPE ALONG TOE (ESTIMATED SEEPAGE \approx 100 GPM)	SIDE PLATE 7 FOR LOCATION OF SEEPAGES HIGH $\frac{1}{2}$ THICK BRUSH PRECLUDES ADEQUATE INSPECTION OF TOE AREA.
STAFF GAGE AND RECORDER	NONE FOUND	
DRAINS	NONE FOUND	

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

NAME OF DAM TYRONE RES. #2
ID# NDI: 535 DEP: 7-2

VISUAL EXAMINATION OF ANY NOTICEABLE SEEPAGE	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	EARTH FIL DAM. N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

NAME OF DAM TYRONE RES. #2
ID# NDI: 535 DER: 7-2

VISUAL INSPECTION
PHASE I
CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	EARTH FILL DAM N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS STAFF GAGE OF RECORDER:	N/A	

VISUAL INSPECTION
PHASE 1
OUTLET WORKS

NAME OF DAM TYBONE RES. #2

ID# NDI: 535 DER: 7-2

VISUAL EXAMINATION OF CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	OUTLET PIPE CAST IRON. ONLY DOWN STREAM END IS VISIBLE. BLOW-OFF PIPE $\phi 20"$	
INTAKE STRUCTURE	INTAKE TOWER. (TOWER IS ACCESSIBLE BY BOAT ONLY)	
OUTLET STRUCTURE	NO OUTLET STRUCTURE. PIPE WOULD DIRECTLY DISCHARGE INTO OUTLET CHANNEL.	
OUTLET CHANNEL	EARTH CHANNEL.	
EMERGENCY GATE	BOROUGH PERSONNEL OPERATED THE BLOW-OFF PIPE VALVE, FOUND TO BE FUNCTIONAL.	

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

NAME OF DAM TYCONE RES #2
ID# NDI: 535 DER: 7-2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	OVERFLOW WEIR. 2-FT HIGH FLASHBOARDS ACROSS THE SPILLWAY CREST.	
APPROACH CHANNEL	FREE OF DEBRIS	
DISCHARGE CHANNEL	RECTANGULAR CONCRETE CHANNEL GOOD CONDITION.	
BRIDGE AND PIERS	WOODEN PEDESTRIAN BRIDGE ACROSS DISCHARGE CHANNEL.	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

NAME OF DAM TYBONE RES #2
ID# NDI: 535 DEC: 7-2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	NO GATED SPILLWAY.	
	N/A.	
APPROACH CHANNEL		
	N/A.	
DISCHARGE CHANNEL		
	N/A.	
BRIDGE PIERS		
	N/A.	
GATES AND OPERATION EQUIPMENT		
	N/A.	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

NAME OF DAM TYRONE RES. #2

ID# NDI: 525 DER: 7-2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE FOUND	
OBSERVATION WELLS	NONE FOUND	
WEIRS	AN ABANDONED SEEPAGE WEIR ON OUTLET PIPE DISCHARGE CHANNEL.	
PIEZOMETERS	NONE FOUND	
OTHER	NONE FOUND	

NAME OF DAM TYEDONE RES. #2
 ID# NDI:535 DER:7-2

VISUAL INSPECTION
 PHASE I
 RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	WOODED , STEEP.	
SEDIMENTATION	UNKNOWN	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

NAME OF DAM TYRONE RES. #2
ID# NDI: 525 DER: 7-2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	NO DOWNSTREAM CHANNEL. FLOW FROM THE DAM DIRECTLY DISCHARGES INTO TYRONE #1 RESERVOIR	
SLOPES	N/A.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	FAILURE OF THIS DAM WOULD RESULT IN FAILURE OF DOWNSTREAM (RES #1) DAM ALSO AND COMBINED DISCHARGE WOULD FLOW THROUGH TYRONE HOMES: 100-200 POPULATION: 500-1000	

APPENDIX B
CHECKLIST
ENGINEERING DATA, DESIGN,
CONSTRUCTION, OPERATION
PHASE I

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM TYRONE RES. #2
ID# NDI: 535 DER: 7-2

ITEM	REMARKS
AS-BUILT DRAWINGS	LIMITED NUMBER OF DRAWINGS ARE AVAILABLE STATE FILES.
REGIONAL VICINITY MAP	SEE PLATE 1
CONSTRUCTION HISTORY	DESIGNED & CONSTRUCTED BY TYRONE GAS AND WATER COMPANY. CONSTRUCTION WAS COMPLETED IN 1912
TYPICAL SECTIONS OF DAM	SEE PLATES 2 AND 3
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	SEE PLATE 2. (INTAKE TOWER IS ACCESSIBLE BY BOAT ONLY)

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM TYRONE RES. #2
ID# NDI 535 DER:7-2

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	NOT RECORDED
DESIGN REPORTS	NOT AVAILABLE . (SEVERAL STATE INSPECTION REPORTS DESCRIBE THE DESIGN OF THE DAM)
GEOLOGY REPORTS	NOT AVAILABLE .
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	NOT AVAILABLE .
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	NOT AVAILABLE .

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM TRYCONE BES #2
ID# NDI:535 DEC:7-2

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	NONE REPORTED.
BORROW SOURCES	LAKE AREA.
MONITORING SYSTEMS	NONE.
MODIFICATIONS	IN ABOUT 1920 AN ADDITIONAL FILL WAS PLACED ON THE DOWNSTREAM SLOPE ON A 2 1/2" HORIZONTAL TO 1 VERTICAL SLOPE. SPILLWAY WAS REBUILT IN 1956. IN ADDITION TO THE MAJOR CHANGE, DAM RECEIVED NUMEROUS OTHER REPAIRS.
HIGH POOL RECORDS	ACCORDING TO A TRYCONE BOROUGH WATER INVESTIGATION LETTER DATED APRIL 29, 1936, MAX. FLOW OVER THE SPILLWAY DURING MARCH-1936 FLOOD WAS 28 INCHES

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM TYBONE RES. #2
ID# NDI:535 DER:7-2

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	VARIOUS REPORTS ON THE POST CONSTRUCTION CHANGES AND REPAIRS ARE AVAILABLE IN STATE FILES.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	DAM WAS BREACHED DUE TO OVERTOPPING DURING CONSTRUCTION (1911).
MAINTENANCE OPERATION RECORDS	NOT AVAILABLE
SPILLWAY PLAN SECTIONS DETAILS	SEE PLATES 1, 2 & 3.
OPERATING EQUIPMENT PLANS AND DETAILS	NOT AVAILABLE.

NAME OF DAM TYRONE RES. #2

ID# NDI: 535 DEC: 7-2

CHECKLIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: WOODED 5.9 SQ. MILES.
ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 460 AC-FT @ EL 1222
ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: SAME AS ABOVE
ELEVATION; MAXIMUM DESIGN POOL: EL 1222 (USGS DATUM)
ELEVATION; TOP DAM: EL 1227

CREST: (SPILLWAY)

- a. Elevation EL 1222 (TOP OF 2-FOOT FLASHBOARDS)
- b. Type CONCRETE OVER FLOW SECTION
- c. Width ~ 2 FT
- d. Length 80 FT.
- e. Location Spillover RIGHT OF SPILLWAY - OVER EMBANKMENT
- f. Number and Type of Gates 2-FT HIGH FLASH BOARDS.

OUTLET WORKS:

- a. Type 20-INCH CAST IRON BLOW-OFF PIPE.
- b. Location MIDDLE OF DAM THROUGH EMBANKMENT
- c. Entrance Inverts 1177 ± (ESTIMATED)
- d. Exit Inverts 1175 ± (ESTIMATED)
- e. Emergency Draindown Facilities 20-INCH BLOW-OFF PIPE

HYDROMETEOROLOGICAL GAGES:

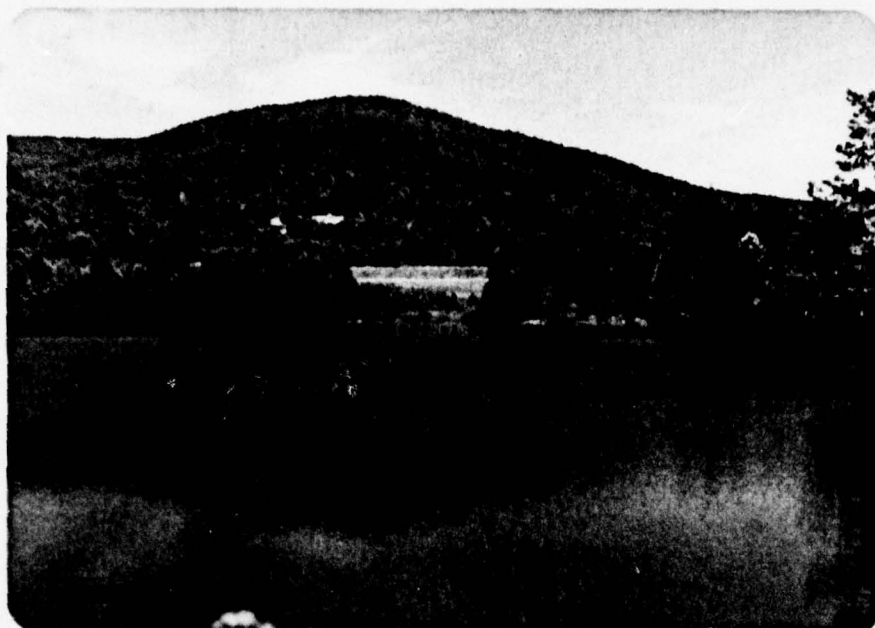
- a. Type NONE
- b. Location NONE
- c. Records NONE

MAXIMUM NONDAMAGING DISCHARGE: 2500 CFS (SPILLWAY CAPACITY OF DOWNSTREAM RESERVOIR)

APPENDIX C
PHOTOGRAPHS

LIST OF PHOTOGRAPHS
TYRONE RESERVOIR NO. 2
NDI I.D. NO. 535
JULY 12, 1978

<u>PHOTOGRAPH NO.</u>	<u>DESCRIPTION</u>
1	Tyrone Reservoir No. 2 (background). Tyrone Reservoir No. 1 (foreground).
2	Crest.
3	Spillway crest (note flash boards).
4	Spillway discharge channel.
5	Blow-off pipe outlet (submerged).
6	High brush on downstream slope.
7	Seepage in blow-off pipe discharge channel (note abandoned weir).
8	Seepage from toe (typical).



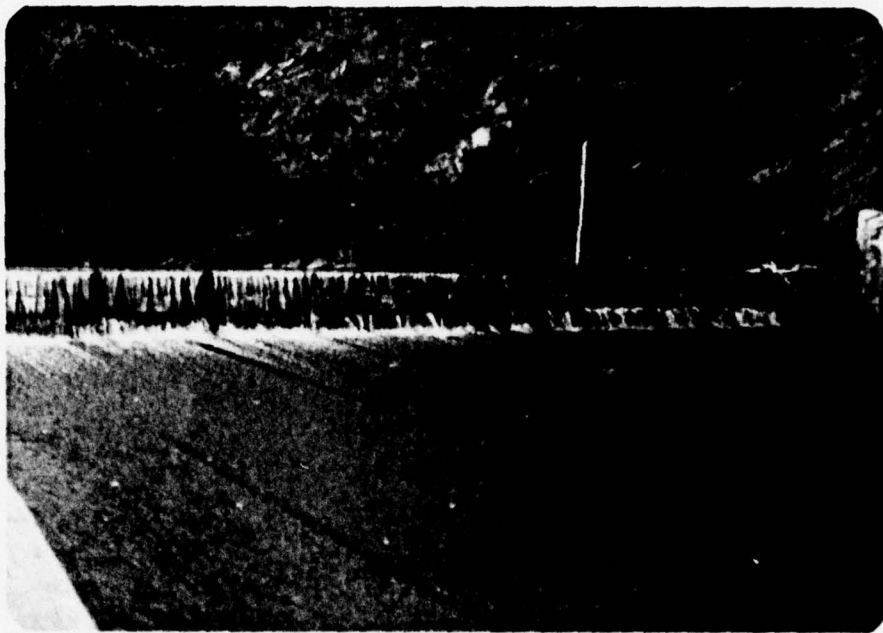
Photograph No. 1

Tyrone Reservoir No. 2 (background).
Tyrone Reservoir No. 1 (foreground).

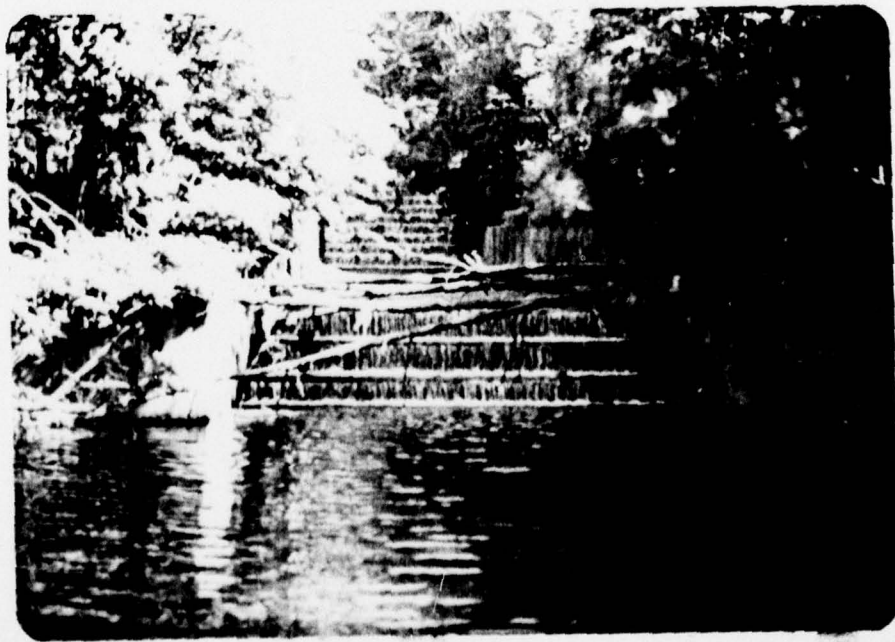


Photograph No. 2

Crest.



Photograph No. 3
Spillway crest (note flash boards).



Photograph No. 4
Spillway discharge channel.



Photograph No. 5
Blow-off pipe outlet (submerged).



Photograph No. 6
High brush on downstream slope.



Photograph No. 7

Seepage in blow-off pipe discharge channel
(note abandoned weir).



Photograph No. 8

Seepage from toe (typical).

APPENDIX D
CALCULATIONS

DIAPYDIONIA

CONSULTING ENGINEERS INC

By WTC Date 8-11-78 Subject TYRONE RESERVOIR NO 2 Sheet No 1 of 2
 Chkd. By WTC Date 8/21/78 HYDROLOGY & HYDRAULIC Proj No 78-114-20

DAM: TYRONE RESERVOIR

WATERSHED AREA: 5.9 SQ. MILE

INFLOW HYDROGRAPH BASIN, SUSQUEHANNA RIVER BASIN
 REGION NO 1, SINK RUN

ACCORDING TO THE SINK RUN PROJECT DATA OBTAINED FROM
 CORP OF ENGINEER BALTIMORE DIST. THE PEAK DISCHARGE
 OF PMF $Q_p = 10000 \text{ cfs}$ for WATERSHED AREA OF
 6.1 SQ MILE, OR $q_p = 1639 \text{ cfs/SQ MILES}$

THEN THE PEAK DISCHARGE FOR SITE

$$Q_p = 5.9 \times 1639 = 9670 \text{ cfs} \quad \boxed{\text{Say } 9700 \text{ cfs}}$$

$$V_i = \frac{26}{12} \times 5.9 \times 640 = 8181 \text{ ac-ft} \quad \boxed{\text{Say } 8200 \text{ ac-ft}}$$

RESERVOIR STORAGE CAPACITY BETWEEN Spillway (1222) & T/DAM (1227)

EL	AREA
1222	21
1227	24

$$VOLUME = \frac{5}{3} (21 + 24 + \sqrt{21 \times 24}) = 112.4 \text{ ac-ft}$$

$$\boxed{\text{Say } 115 \text{ ac-ft}}$$

SPILLWAY CAPACITY

TYPE OVER FLOW WEIR w/ 2' FLASH BOARD
 LENGTH = 80.5' ±

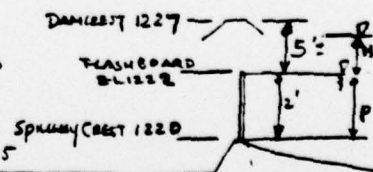
$$Q_s (\text{WITH FLASH BOARD}) = C L H^{1.5}$$

$$\text{Sharp crest} = (5.3)(80.5)(5)^{1.5} = 2970 \text{ cfs} \quad \boxed{\text{Say } 3000 \text{ cfs}}$$

$$Q_s (\text{WITHOUT FLASH BOARD}) = (2.7)(80.5)(7)^{1.5}$$

$$= 4025 \text{ cfs} \quad \boxed{\text{Say } 4000 \text{ cfs}}$$

Board crest



DAPIPOLONA
CONSULTING ENGINEERS, INC.

By WTC Date 8-11-78 Subject TYPANTZ NO. 2 Sheet No. 2 of 2
Chkd By MB Date 8/23/78 HYDROLOGY & HYDRAULIC Proj. No. 78-114-20

FLOOD SURCHARGE STORAGE VOLUME

LAKE AREA ≈ 23 ACRES

$$VOL = V_s \approx 23 \text{ acres} \times h$$

$$= 23 \times 5 = 115 \text{ ac-ft (WITH FLASH BOARD)}$$

$$\text{OR } \approx 23 \times 7 \approx 161 \text{ ac-ft (WITHOUT FLASH BOARD)}$$

PERCENT OF PMF WITHOUT OVERTOPPING

a) WITH FLASH BOARD

$$\left(\frac{3000}{9700} + \frac{115}{8200} \right) 100\% = 32.3\% \text{ say } 32\% \text{ PMF}$$

b) WITHOUT FLASH BOARD

$$\left(\frac{4000}{9700} + \frac{161}{8200} \right) 100\% = 43.2\% \text{ say } 43\% \text{ PMF}$$

CONCLUSION: THE SPILLWAY IS SERIOUSLY INADEQUATE FOR PMF

APPENDIX E
REGIONAL GEOLOGY

APPENDIX E REGIONAL GEOLOGY

Tyrone Reservoirs Nos. 1 and 2 are located on the northwest edge of the folded belt of the Appalachian Mountains. The two reservoirs are on the boundary between the Catskill Formation and the underlying Chemung Formation (both Devonian Age), with the strata dipping moderately in a northwest direction.

The upper reservoir is on the Catskill Formation which consists of thin-bedded, highly fractured reddish-brown claystone and shale with some interbedded sandstone beds. The finer grained strata are easily weathered while the more resistant sandstone forms stable, moderately steep slopes.

The lower reservoir is located on rock of the Chemung Formation which consists of thin-bedded greenish-gray shales with some interbedded fine-grained sandstone layers. The shales are fractured and weather easily, while the sandstone is moderately resistant to weathering.

Small rock falls may occur where the less resistant claystone and shales are eroded below sandstone layers. This occurs in both the Catskill and Chemung Formations.